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Structure of "Quantum Wires" in Au/Si(557)

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"Quantum wires" are structures that closely approximate the one-dimensional (1D) electron gas paradigm. A fundamental question about 1D systems is whether spin and charge properties of the electron state can become separated, as proposed by Luttinger [1]. Intriguing electronic properties have been discovered experimentally, such as a splitting of the 1D electron band structure into two states, symmetrically positioned about the zone center at the Fermi level [2]. At present there is no explanation accepted for this result, which was announced to be "spin-charge separation". Electronic band-structure calculations should be able to resolve the issue, but not without full prior knowledge of the full 3D atomic structure.

We studied Au/Si(557), a surface vicinal to Si(111) with Au decorating its step edges, which forms 1D wires. Because STM is unable to obtain the structure in sufficient detail, we used surface x-ray diffraction, helped by the fact that the Si(557) steps are arrayed with fairly long-range order. The result of our analysis so far (Sept 2001) is shown as a side view atomic model in the figure below. Variations of the structure are presently being tested. The big atoms are Au and the small atoms Si. The work was supported by the NSF and the DOE.

[1] J. M. Luttinger, "An exactly soluble model of a many-fermion system", J. Math. Phys. 4, 1154-1162 (1963)

[2] P. Segovia, D. Purdie, M. Hengsberger and Y. Baer, "Observation of spin and charge collective modes in one-dimensional metallic chains", Nature, 402, 504-507 (1999)